

Porosity and pore size distribution of materials

Part 4. Method of evaluation by liquid expulsion

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Foreword

This Part of BS 7591 has been prepared under the direction of the General Mechanical Engineering Standards Policy Committee and is one of a series which describes recommended methods for the evaluation of porosity and pore size distribution.

This Part of BS 7591 describes the evaluation of porosity by liquid expulsion. Other Parts of BS 7591 are as follows:

Part 1. *Method of evaluation by mercury porosimetry*

Part 2. *Method of evaluation by gas adsorption*

¹⁾ Part 3. *Method of evaluation by challenge test*

This British Standard describes a method of evaluation only and should not be used or quoted as a specification defining limits of performance. Reference to this British Standard should indicate that the method of evaluation used is in accordance with BS 7591 : Part 4 : 1993.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

¹⁾ In preparation

Method

Introduction

In general, different types of pores can be pictured as either apertures, channels or cavities within a solid body or as the space (i.e. interstices or voids) between solid particles in a bed, compact or aggregate. Porosity is a term which is often used to indicate the porous nature of solid material and is more precisely defined as the ratio of the volume of accessible pores and voids to the total volume occupied by a given amount of the solid. In addition to the accessible pores, a solid can contain closed pores which are isolated from the external surface and into which fluids are not able to penetrate. The characterization of closed or blind pores is not covered in this Part of this standard.

Porous materials can take the form of fine or coarse powders, compacts, extrudates, sheets or monoliths. Their characterization usually involves the determination of the pore size distribution as well as the total pore volume or porosity. For some purposes it is also necessary to study the pore shape and interconnectivity and to determine the internal and external surface area.

Porous materials have great technological importance, for example in the context of:

- controlled drug release;
- catalysis;
- gas separation;
- filtration including sterilization;
- materials technology;
- environmental protection and pollution control;
- natural reservoir rocks.

It is well established that the performance of a porous solid (e.g. its strength, reactivity, permeability or adsorbent power) is dependent on its pore structure. Many different methods have been developed for the characterization of pore structure. In view of the complexity of most porous solids, it is not surprising to find that the results obtained are not always in agreement and that no single technique can be relied upon to provide a complete picture of the pore structure. The choice of the most appropriate method depends on the application of the material, its chemical and physical nature and the range of pore size.

The most commonly used methods are as follows.

Mercury porosimetry, where the pores are filled with mercury under pressure. This method is suitable for many materials with pores in the approximate diameter range of 0.003 μm to 400 μm , and especially in the range 0.1 μm to 100 μm .

Gas adsorption, where the pores are characterized by adsorbing a gas, such as nitrogen, at liquid nitrogen temperature. This method is most appropriate for pores in the approximate diameter range of 0.0004 μm to 0.04 μm (0.4 nm to 40 nm) and is an extension of the surface area estimation technique (see BS 4359 : Part 1).

Challenge test, where the effective size of the through-pores in a structure is estimated by the passage of test particles or molecules of different sizes. This method is often used for pores in the approximate diameter range of 0.005 μm to 100 μm .

Liquid expulsion, where the through-pores in a structure are characterized by the pressure required to empty them of a wetting fluid. This method is normally used for pores in the approximate diameter range of 0.05 μm to 50 μm .

1 Scope

This Part of BS 7591 describes the evaluation of pore size characteristics (such as mean, maximum and the distribution of pore sizes) that allow the flow of liquid from one side of the wetted structure to the other. It is a comparative and usually non-destructive test. Pore size is commonly expressed as 'pore diameter'. The pore diameter is calculated from the applied gas pressure, which causes the liquid filled pores to be emptied, resulting in a flow of gas through the sample.

The method is suitable for the study of through-pore materials, such as filter paper, paper, polymer membrane filters and cloth. It enables pore sizes to be estimated within the general size range of about 50 μm down to about 0.05 μm .

The test involves the application of pressures up to 1 MPa²⁾ (150 psi). For most materials this pressure does not cause compaction or deformation of the material which would result in a change in the pore structure.

The technique should be considered to be comparative, as for most porous media a theory is not available to allow an absolute calculation of pore size.

It is the recommended method for the evaluation of filter papers (see BS 6410).

2 Informative references

This Part of BS 7591 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

²⁾ 1 Pa = 1 N/m².